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DEPARTMENT OF PSYCHOLOGY

UNIVERSITY OF SOUTHERN CALIFORNIA

BEHAVIORAL TECHNOLOGY LABORATORIES

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Technical Report No. 88

A COMPUTER-BASED TRAINING SYSTEM FOR SELECTIVE TEXT PROCESSING

August 1978

Donald E. Crook, Allen Munro, Joseph W. Rigney
and Kathy A. Lutz

Sponsored by

Personnel and Training Research Programs
Psychological Sciences Division
Office of Naval Research

and

Advanced Research Projects Agency
Under Contract No. N00014-77-C-0328

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Self-directed learning is that type of learning which is not structured for the student by an instructor. Instead, the student must structure his learning himself by making decisions about which materials are relevant to his learning goals, which materials require the prior understanding of which other materials, and so on. A computer-based system has been developed to train students in this type of learning.
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An experimental test of the improved system was designed to separate out the effects of training in self-directed learning from the use of the system itself. Data were collected on four different measures of learning: effective learning, selective learning, planning, and verbal report. Results of the experiment found that there were no significant differences among treatment groups in the performance data (the first three learning measures), even though one of the experimental groups outperformed the other groups in every measure. On the measure of verbal report, however, this experimental group performed significantly better than did the control group.

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SUMMARY

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I. INTRODUCTION

Self-directed learning is that learning which the student directs himself; that is, no structure is imposed on his learning externally. This type of learning is found in many on-the-job learning contexts in which a worker must make his own decisions about just what information will help him solve the problem, but he must not waste his time reading irrelevant information. He must also structure his learning in such a way that if he encounters unfamiliar concepts, he can locate the prerequisite information he needs to understand those concepts. Self-directed learning thus differs dramatically from the type of learning that goes on in the classroom, in which an instructor is available to direct the student's learning. Obviously, skills and strategies necessary for self-directed learning are seldom if ever taught in the classroom.

We have developed a computer-based self-directed learning system, described in Munro, Rigney, and Crook (1978) and in Rigney, Munro, and Crook (in press). Those reports described an early version of this system and the results of a pilot experiment using the system. This report will discuss a revised version of the system and the results of a larger experiment.

In the pilot experiment, some of the subjects used the self-directed learning aid in solving a complex problem, while the other (control) subjects used a simplified version of the learning aid which did not include any of the self-monitoring features of the complete Aids system (described below). (In effect, the control system is nothing more than a computer-based book; as soon as the student selects a title in the table of contents, he is shown the corresponding information.) Data were kept on subjects in both the experimental and control groups while they solved a complex learning task. Various measures were taken, such as time required to solve the task, the number of errors made, and several measures of selectivity and planning. Results showed that while there were no significant differences between the groups, the experimental group on the whole performed slightly better than the control group. More importantly, however, experimental subjects at the low end of an ability scale (as measured by the Nelson-Denny test of reading ability) performed better than control subjects in the same range. It was therefore concluded that the self-directed learning Aid helps students who are poor readers to a greater extent than it helps students who are good readers. The results of this experiment and verbal and written comments made by the subjects suggested certain improvements that could be made both in the automated learning Aid and in the training program that accompanied it. These improvements are incorporated into the current version of the Aids system.

The self-directed learning Aids system consists of the following "pages" or areas of the computer program:

TASK page: contains a statement of the student's learning task

OBJECTIVES page: allows the student to break down the task into a set of sub-goals, called objectives

CONTENTS page: contains a list of the titles of information sources available to the student

RELEVANT CONTENTS page: lists only those titles that the student has selected as relevant to the task.

From any one of these pages, the student can go to any of the others as he wishes; rather than following a strict linear order through the program, the student is free to move around as he deems necessary. Each page has a number of functions which the student may use while on that page. For example, the RELEVANT CONTENTS page lists all those titles of information sources that the student has selected to read. From this page the student may elect to read one of these information sources, check it off if he feels it really is relevant to his learning task, X it off if he feels it is irrelevant, or express dependencies between two information sources (that is, state that one source should be read before the other).

The current version of the automated Aids system differs from that described in Munro, Rigney, and Crook (1978) in a number of ways. New functions have been added to some of the pages, the goal stack has been extensively revised, and the matching section has been eliminated altogether. Previously, students were allowed to proceed in either a conceptually driven (top-down) or data-driven (bottom-up) fashion, although the system more easily provided for the latter. That is, students would select a title and then be asked in the matching section to decide which of the objectives the title was relevant for. There was no overt mechanism available to them to select an objective first and search for titles to help them attain that objective (although they could of course do this mentally). Many students felt that this matching procedure was "backwards," so the current version of the automated Aid was adopted. A student is now led to proceed in a conceptually driven fashion by first selecting an objective to work on, then selecting one or more titles for that objective. Since the match is made as soon as the student selects a title, there is no need for a separate matching section in the Aids system.

Another feature of the Aids system, the goal stack, was modified to make it easier for students to use. Since there is limited space on the screen of the computer terminal, only the number of goals (objectives and titles of information sources) are displayed in the goal stack. A feature was added to the current version to allow the student to touch any of these numbers on the screen and be shown that goal written out in full. The student may also elect to see all the other goals which are related to that goal written out in full, along with the dependency relationships they form with the original goal. New functions which were added include a "Task Analysis" box on the TASK page which helps the student formulate objectives for the specific task domain he is working in, and a "Select" box on the OBJECTIVES page which allows the student to select an objective to work on.

In addition to improvements made to the self-directed learning Aid itself, several improvements were made to the training program which accompanies it. (The Aids system is a rather complex system which requires a number of hours of training in its use before students feel comfortable with it.) Long expository passages in the original version have been broken down into shorter screen displays, and short quizzes appear much more frequently than they did in the earlier training program. In addition, each training session now begins with a quiz reviewing the contents of the previous session. These changes were designed to keep the student more actively involved with the training program.

It was noted after the pilot experiment that experimental subjects had a more difficult learning task than control subjects did. Each training session included sample problems to practice using the automated Aids system, but only the experimental subjects had to learn to use the Aids systems in addition--the control version of the "Aids" system required no training beyond the initial session. Consequently, the current training program used simple practice problems, allowing the students to concentrate fully on the details of the Aids system. These simple problems involved decisions concerning maritime rules of the road. The final (testing phase) session of the training program, however, used a complex learning task. This task required students to troubleshoot or debug a simulation of a sentence generator having one "faulty" component.

Finally, the effects of training in self-direction and the use of the automated Aid were separated in this study. The pilot experiment compared experimental subjects who had both training and the Aids system against control subjects who had neither. The present experiment compared the results of three different groups to evaluate the effects of both training and the use of the automated Aids system.

II. EXPERIMENT

An experiment was conducted to test the effects of the self-directed learning Aid discussed in Section I.

Experimental Design

The experiment was designed to test the following two research hypotheses: (1) students who are trained in self-direction strategies will solve a complex learning task more quickly and efficiently than students who are not trained and (2) when students are trained in self-direction strategies, those students who are provided with the automated Aids system to facilitate the use of those strategies will solve the task more quickly and efficiently than the students who are not provided with the Aids system. Subjects were assigned at random to one of the following conditions:

(I) Training plus Aids system: Students were trained in self-direction strategies and in the use of the Aids system. During the final session (during which data on student performance was collected), they were provided with the Aids system designed to facilitate application of the strategies.

(II) Training and no Aids system: Students were trained in self-direction strategies and in the use of the Aids system in the same way as Group I. During the final session, they were not given the Aids system; instead, they had to accomplish the task using the same apparatus available to the group below.

(III) No training and no Aids system: Students were given no training in self-direction strategies, nor did they have the Aids system available during the final problem-solving session.

The first research hypothesis is tested by comparing the performance of students in Condition II with that of students in Condition III, while the second hypothesis is tested by comparing the performance of students in Condition I with that of students in Condition II. This design is similar to a 2 x 2 factorial except that the cell corresponding to "No training and Aids system" was omitted because students could not be expected to use the complex Aids system without prior training in its use.

During the testing phase, students in the training-only and control groups (Conditions II and III) use an automated system containing only the Task and Contents pages of the system described in Section I. Students in these groups have the same learning task and the same information to read, but they have none of the Aids system available to students in the training-plus-Aids group (Condition I). (Information sources in this simplified system are accessed directly from the Table of Contents. As soon as the student touches a title, he is shown the corresponding information source.)

The training sequence for control subjects is similar to that for the other students, except that the basic system is never modified for them, so there is no need for teaching sessions other than the initial one. Thus, sessions two and three are practice sessions using the control system, and session four is the testing phase. The training phase for students in the training-only group is identical to that for students in the training-plus-Aids group. During the final session, however, the training-only students use the control system rather than the self-directed learning Aids system. The combinations of different systems used in all three conditions are shown in Figure 1.

	Condition		
	I	II	III
Training	Aids System	Aids System	Control System
Test	Aids System	Control System	Control System

Figure 1. Combinations of Systems Available to Subjects in Each Condition.

Method

Subjects for the experiment were volunteers recruited from a lower-level NROTC course at a major university. Thirty-nine subjects were assigned at random to each of the three conditions discussed above. The students were told that they would receive exposure to junior-level NROTC course material by participating in the experiment as well as twenty dollars for completing the experiment. During the test session, they were told that they could receive an additional two dollars for solving the task correctly on the first attempt or an additional one dollar for solving it on the second attempt. The reason for this bonus was to discourage random guessing and to encourage students to have a fair degree of confidence in their answer.

Data Collection

The data collected during the final session were designed to measure both effective learning and self-directed learning. *Effective learning* is defined in terms of the time spent reading information and the number of errors made in attempting to solve the task. Data are collected for each student on the number of erroneous attempts (wrong answers) made when the student attempts to perform the task and the total time the student spends reading information sources to solve the task. *Self-directed learning* is much more difficult to measure, but it seems to be typified by two phenomena: planning and selectivity in the use of available information sources. The data collected reflect operational definitions of these phenomena.

Planning

It is not an easy matter to discover whether a student is engaged in effective planning. One type of data saved by our PLATO program is the sequence in which students accessed the information resources available to them. Our analysis of the troubleshooting task presented to the students in the testing phase has resulted in the formulation of a set of rules for scoring deviations from the order in which the information sources should be accessed. These rules, which we call anti-precedence rules, take the form of prohibitions of certain sequences. The extent to which a student has departed from sequences permitted by an ideal task analysis can be expressed in terms of the number of times the student's study sequence violates the anti-precedence rules.

Basically, the anti-precedence rules require that the student not read about a subcomponent of the sentence generator unless he has first read about the component which contains it. A particular rule is violated if the student either fails to read about the larger component or reads about it after reading about the subcomponent. These rules thus reflect the idea that a student should not attempt an action until he has completed its prerequisite.

Selectivity in the Use of Information Sources

Selectivity has to do with reading information sources which are relevant to the learning task and not reading the irrelevant information sources. The ratio of relevant information sources read to all information sources read is a measure of selectivity; a student for whom this ratio is high has read primarily relevant sources and few irrelevant ones. Two different ratios of this type were computed, the first a ratio of the number of information sources read and the second a ratio of the time spent reading those information sources. That is, the first is the ratio of the number of relevant information sources read to the total number of information sources read, and the second is the ratio of the time spent reading relevant information sources to the time spent reading all information sources.

Subject Strategy Summaries

In addition to collecting data on effective learning and self-directed learning, we attempted to validate the schema representations given in the Appendix. Following the final session, students were asked to describe the "learning techniques or strategies" that they used in solving the complex troubleshooting task. Their summaries of these strategies were analyzed using a modified form of the method for scoring text recalls and summaries described in Gordon, Munro, Rigney, & Lutz (1978), to try to determine if subjects in different treatment groups would summarize their strategies differently. This method of text analysis examines summaries for occurrences of statements of particular relevance for self-directed learning, that is, the representations presented in the Appendix. These were translated into short English statements, and three judges scored the summaries of strategies for the presence of these statements.

Results

For each of the three treatment groups, means and standard deviations were computed for the dependent measures and individual differences variables. The means for the dependent measures are presented in Table 1, and the means for the individual difference measures are given in Table 2. Visual inspection of the results presented in Table 1 reveals that the training-only group performed worse than both the training-plus-aids and the control groups on almost every measure. In retrospect, this result seems unsurprising, since the training in self-direction that the subjects were given was, for the most part, either oriented toward or interpretable in terms of the functions of the Aids system. Students in the training-only group were required to solve a complex problem in the final session using an "aids" system with which they were unfamiliar. The comparison of the training-plus-aids group to the control group will therefore be emphasized below.

The number of errors made in solving the complex problem is a measure of the effectiveness of the learning strategies that students use to accomplish their task. Although a paired comparisons test did not reveal a significant difference between the two groups of interest, inspection of the descriptive statistics indicates that the control group made slightly more errors on the average and varied more widely in their performance. The variance of the control group is about twice that of the treatment group. This suggests that the treatment served to reduce individual variation in complex problem solving. A second measure of learning effectiveness is the amount of time spent reading the information resources. The training-plus-aids group spent less time reading the information than the control group, but again the difference did not reach significance.

The other three variables included in Table 1 are measures of self-directedness during problem solving that require the use of text. All

Table 1

Means and Standard Devistions
of Dependent Measures

Variables		Training + Aids	Training-Only	Control
Reading Time (minutes)	$\overline{X}$	20.05	41.89	27.44
	SD	(14.71)	(33.93)	(13.12)
Errors	$\overline{X}$	1.23	3.31	1.62
	SD	(1.54)	(3.20)	(3.02)
Selectivity in Titles Picked	$\overline{X}$	.77	.61	.68
	SD	(.17)	(.17)	(.22)
Selectivity in Time Allocation	$\overline{X}$	.71	.62	.67
	SD	(.20)	(.18)	(.24)
Planning Violations	$\overline{X}$	1.39	1.54	1.58
	SD	(1.50)	(1.13)	(1.56)

(Treatment Conditions: Training + Aids, Training-Only, Control) differences between the two groups are in the predicted direction but are not significant. Students in the training-plus-aids group were somewhat more selective in choosing only relevant titles and also spent more of their time reading relevant information than did the controls. The treatment conditions also resulted in fewer planning violations than did the control condition.

Therefore, as assessed both by final performance and by behaviors during problem solving, the treatment condition produced slightly (but not significantly) more effective and self-directed learning.

Individual differences in learner ability were compared across groups. No differences were found, indicating that the randomization procedure successfully yielded similar groups. Scores on both verbal and mathematics sections of the Scholastic Aptitude Text (SAT) were obtained, and group means of these scores are shown in Table 2.

All variables were correlated with one another, and the overall correlation matrix is shown in Table 3. Several relationships are noteworthy. There were strong relationships between error scores and the two measures of selectivity, $\underline{r} = -.57$ and $-.51$ ($\underline{p} < .05$) for reading choice and time allocation respectively. These strong negative correlations between errors and selectivity indicate that greater selectivity during problem solving corresponds to fewer errors. This finding is important because it suggests that selectivity, as operationally defined in this study, does in fact result in more effective learning. In other words, selectivity does result in better problem-solving performance.

Another interesting relationship is that found between errors and reading time, $\underline{r} = .32$ ($\underline{p} < .05$). Apparently, as students spent more

Table 2

Means and Standard Deviations of
Individual Difference Measures

Variables		Treatment Conditions		
		Training + Aids	Training-Only	Control
SAT: Verbal	$\bar{X}$	588	542	566
	SD	(85)	(57)	(76)
SAT: Math	$\bar{X}$	637	635	615
	SD	(58)	(41)	(64)
SAT: Composite	$\bar{X}$	1225	1184	1185
	SD	(85)	(75)	(105)

Table 3

Combined Correlation Matrix

	A	B	C	D	E	F	G
A. Reading Time							
B. Errors	.31*						
C. Selectivity 1 (title choice)	-.28	-.57*					
D. Selectivity 2 (time allocation)	-.24	-.51*	.90*				
E. Planning Violations	.06	.17	-.55*	-.64*			
F. SAT: Verbal	-.01	-.40*	.10	-.02	.03		
G. SAT: Math	-.01	-.27	.16	.18	-.06	-.14	
H. SAT: Composite	-.02	-.54*	.14	.10	-.01	.78*	.52*

Note. N = 39 except due to missing data

* $p < .05$

time reading the information, they tended to perform worse (make more errors). This positive relationship between reading times and errors is opposite of the expected relationship between time and performance--namely, that the more time a student spends learning the better he or she should do on a criterion test. The relationship observed in this study suggests that students who were more efficient (who spent less time reading) were also more effective in that they solved the task with fewer errors. Further support for this conclusion is found in the inverse relationship between reading time and selectivity, $r = -.28$ (title choice) and $r = -.24$ (time allocation). While neither of these correlations is significant, the negative tendency suggests that students who were more selective tended to take less reading time to solve the problem.

Finally, it is interesting to note the strong correlations among the three measures of self-direction--selectivity in title choice, selectivity in time allocation, and planning violations. The two selectivity ratios are strongly related, $r = .90$ ($p < .05$). This relationship suggests that students who selected the appropriate information to read also allocated their time to reading that information. The selectivity measures are negatively related to planning errors, $r = -.55$ and $-.64$ ($p < .05$) for title choice and time allocation, respectively. The negative relationships suggest that students who choose selectively and spent most of their time reading appropriate information did so according to the proper sequence. The three measures of self-direction used in this study were therefore, consistent in their assessment of student behaviors.

Aptitude by Treatment Interactions (ATI)

The combined correlation matrix cannot reveal any differences between the treatment conditions. Therefore, correlations between variables were examined for each treatment group individually. These correlations appear in Tables 4, 5, and 6. Visual examination of the data indicates an overall pattern of differences between the three treatment groups. In general, the expected relationships between ability, time, and performance occur only in the control condition. For example, we would expect students of higher verbal ability to need less reading time to solve the problem (and lower ability students to require more reading time). Yet, the expected negative correlation between these two variables (verbal ability and reading time) occurred only in the control condition, r = .50, .05, and -.48 for training + aids, training, and control groups, respectively. The correlations between verbal ability and error scores also fail to be strongly negative except for the control group, r = -.18, -.12 and -.71 respectively. In other words, only in the control condition was the negative correlation significant ($p < .05$). Ability, then, is predictably related to the dependent measures only in the control condition.

The relationship between ability and self-direction also seems to fit our expectations only in the control group. We would expect students of higher verbal ability to be more selective and make fewer planning violations. Although we would predict that verbal ability and selectivity are positively related, a positive correlation between ability and selectivity in time allocation occurred only in the control condition, r = -.38, -.47, and .55 respectively. Similarly, the correlation between ability and selectivity in title choice was positive only for control subjects,

Table 4

Correlation Matrix for Training+Aids Group

	A	B	C	D	E	F	G
A. Reading Time							
B. Errors	.35						
C. Selectivity 1 (title choice)	-.21	-.40					
D. Selectivity 2 (time allocation)	-.14	-.09	.83*				
E. Planning Violations	.30	.03	-.61*	-.67*			
F. SAT: Verbal	.50*	-.18	-.12	-.38	.27		
G. SAT: Math	-.15	-.26	.41	.53	-.26	-.33	
H. SAT: Composite	.39	-.35	.16	-.01	.09	.77*	.35

Note: N = 13 except due to missing data

$p < .05$

Table 5

Correlation Matrix for Training-Only Group

	A	B	C	D	E	F	G
A. Reading Time							
B. Errors	.23						
C. Selectivity 1 (title choice)	-.08	-.60*					
D. Selectivity 2 (time allocation)	-.09	-.57*	.91*				
E. Planning Violations	-.10	-.23	-.32	-.49*			
F. SAT: Verbal	.05	-.12	-.49	-.47	.44		
G. SAT: Math	-.35	-.55*	.49	.35	.19	-.14	
H. SAT: Composite	-.19	-.53*	-.01	-.09	.36	.78*	.51

Note: N = 13 except due to missing data

$p < .05$

Table 6

Correlation Matrix for Control Group

	A	B	C	D	E	F	G
A. Reading Time							
B. Errors	.28						
C. Selectivity 1 (Title choice)	-.67*	-.55*					
D. Selectivity 2 (time allocation)	-.67*	-.62*	.97*				
E. Planning Violations	.16	.59*	-.69*	-.72*			
F. SAT: Verbal	-.48	-.71*	.46	.55	-.50		
G. SAT: Math	.59*	-.21	-.18	-.17	-.03	.72*	
H. SAT: Composite	.03	-.67*	.08	.23	-.28	.78*	.68*

Note: N = 13 except due to missing data

$p < .05$

$\underline{r}$ = -.12, -.49, and.46 respectively. Furthermore, we would expect that verbal ability is inversely related to violations in planning, yet the obtained correlations did not match that prediction except in the control condition, $\underline{r}$ = .27, .44, and -.50 respectively. Hence, the expected relationships between verbal ability and measures of self-directedness did not hold except for students in the control condition.

Several other expected relationships held only for the control condition. We would expect that selectivity would decrease reading time so that these variables should be negatively correlated. While the correlations are negative for all three groups ($\underline{r}$ = -.21 and -.14 for training-plus-aids, $\underline{r}$ = -.08 and -.09 for training-only, and $\underline{r}$ = -.67 and -.67 for control), they are significant only in the control group. The final prediction is that planning violations should be related to errors because inefficient learners are probably ineffective as well. The correlations are $\underline{r}$ = .03, -.23, and .59, respectively. In other words, the naturally expected correlation between planning violations and errors is found only in the control condition.

The ATI evidence shows that expected relationships between ability and performance held only for the control group. It seems likely that students of high ability in the experimental groups may have been hampered by the cumbersome mechanics of the Aids system, which promoted less efficient strategies than they would have used on their own. Less capable students in the experimental groups, who may have had no useful strategies, were probably helped by the features of the Aids system. This explanation is supported by the reduced variance in errors found in the training plus aids group as compared with the control group.

Strategy Summary Results

Means and standard deviations for the scored strategy summaries are given in Table 7. A 2-factor analysis of variance (ANOVA) with repeated measures on the rater factor was performed on these data, and the results appear in Table 8. Differences among the treatment conditions are significant, $F = 5.34$, $p < .01$. Although differences among the raters are also significant, the interaction between the two factors is not significant ($F = 1.93$, N.S.), indicating that group differences in reported strategies are not a function of rater bias. Therefore, strategy scores were averaged across raters (the inter-rater reliability coefficient is .81). The resultant group means are shown in Table 9. Differences between the training-plus-aids and the training-only groups are significant ($t\ (24) = 2.93$, $p < .01$), and the differences between the training-plus-aids and the control group are also significant ($t\ (24) = 2.38$, $p < .05$). We may conclude, then, that students in the training-plus-aids group learned significantly more of the self-direction learning strategies than did students of either of the other two groups.

Why students in the training-plus-aids group should report different strategies than those in the training-only group is difficult to understand. One explanation that seems likely relies upon the fact that students were instructed to produce summaries "that you used to solve the problem you just worked on." As we have already seen in the performance data, students in the training-only group performed quite poorly. It seems likely that they were not making use of the self-directed learning strategies during the final session. The fact that they did not produce summaries of the self-direction strategies does not necessarily mean that

Table 7

Means and Standard Deviations of Strategy Summary Judgements

Raters		Treatment Condition		
		Training + Aids	Training-Only	Control
I	$\overline{X}$	1.5	0.5	0.6
	SD	(1.3)	(.7)	(.9)
II	$\overline{X}$	3.5	1.9	2.9
	SD	(1.8)	(1.6)	(1.4)
III	$\overline{X}$	3.0	1.5	1.4
	SD	(1.6)	(1.4)	(1.3)

Table 8

ANOVA Summary Table for Strategy Summary Judgements

Source	df	MS	F
Between Treatment Condition	2	19.56	5.34*
$Error_b$	36	3.67	
Within Raters	2	35.41	37.55*
Interaction	4	1.821	1.931
$Error_w$	72	.94	

$p < .01$

Table 9

Averaged Strategy Summary Judgements

	Treatment Condition		
	Training + Aids	Training-Only	Control
$\overline{X}$	2.7	1.3[a]	1.6[b]
SD	(1.4)	(1.0)	(0.9)

[a] $p < .05$ for comparison to Training + Aids group.

[b] $p < .05$ for comparison to Training + Aids group.

they did not learn the strategies. Rather, they may have simply been obeying the instructions by not describing the strategies that they failed to use.

Discussion

Our analyses of the data on self-direction and reading effectiveness found no significant differences due to group. Therefore, the results did not support either of our research hypotheses (that training in self-directed learning would improve performance and that use of the aids system would further improve performance). There was, however, a non-significant tendency in the data for those students who had both received training and had the use of the aids system during the test to perform better than the students in the other two groups. It is possible that with more training practice or with more subjects these results might have reached significance. It is noteworthy that the training-plus-aids group outperformed the other two groups on each of the performance measures we took. On only one measure, the scores for summarized strategies, did the performance of the training-plus-aids group significantly exceed that of the other two groups. Interpretation of this result is problematic. Those students who were both trained in the use of the self-directed learning aids system and given access to that system in the test session were able to later summarize the principles of the system in writing. Yet other students who had received the same training (the training-only group) but did not practice with it in the last session were no better than control subjects at expressing the strategies.

An unexpected aspect of our results was the (non-significant) difference between the control group and the group that was trained in the use of the aids system but did not have the use of that system during the test. We had predicted that the training-only group would perform less well than the training-plus-aids group, but better than the control group. Instead, control group students did better than those in the training-only group. In retrospect, this result seems quite natural. students in the training-only group received training in the use of one computer-based aids system but were tested on their facility with another. The switch in systems may well have been confusing, and this could have caused their performance to deteriorate. Another possibility, however, is that training in the use of the experimental aids system does not improve one's ability to learn in a self-directed, selective way. Perhaps, on the contrary, it creates a kind of intellectual dependence on the facilities of the aids system. When these facilities are removed, those who have been trained in their use perform less well than those who have not been exposed to the aids system. Given the nonsignificance of the results, such conclusions are, at best, merely speculative.

An interesting aspect of the results is the finding that different learning measures are related. The two measures of effective learning (reading time and errors) are significantly correlated, as are the three measures of self-directed learning (two selectivity ratios and planning violations). The question naturally presents itself: Is effective learning related to self-directed learning? Of six possible relationships, only one was found to be significant--selectivity of title choice is inversely related to number of errors. In the control condition, however, three other relationships emerge. Both selectivity ratios are inversely related to reading times, and planning violations are directly related to errors made in attempting the task. Why should these relationships appear only in the control condition? Scatter diagrams of these relationships show that the control condition represents the expected relationship. For example, Figure 2 plots selectivity of title choice against reading time. For students in the control condition, the less selective they are, the more time they spend reading. This relationship does not seem to hold for the students in the training-plus-aids group, however.

The results of the research reported here lend support to two conclusions that we believe are also supported by other recent results in cognitive research. The first is that human learning and human thinking are not very general processes, but are always closely linked to fairly detailed or specific situations. The second conclusion is that human learning strategies or skills are highly automatized; as a result, even inefficient learning strategies may lead to superior performance when they are compared to the use of non-automatic strategies. In the remainder of this paper we will present evidence for these two claims and discuss their implications for training research.

A number of theorists in cognitive science (for example, Goldstein & Papert, 1977) have recently proposed that models of human thought should include few, if any, general processes. Rather, knowledge and thought are best represented as a collection of quite specific concepts, concepts that are bound to particular restricted entities in particular situations. If this claim has substance, it may be that the strategies that subjects in our training groups learned were somehow closely bound up in their minds with the topic matter of the example learning problems that were used during training. In the training sessions, subjects were given problems

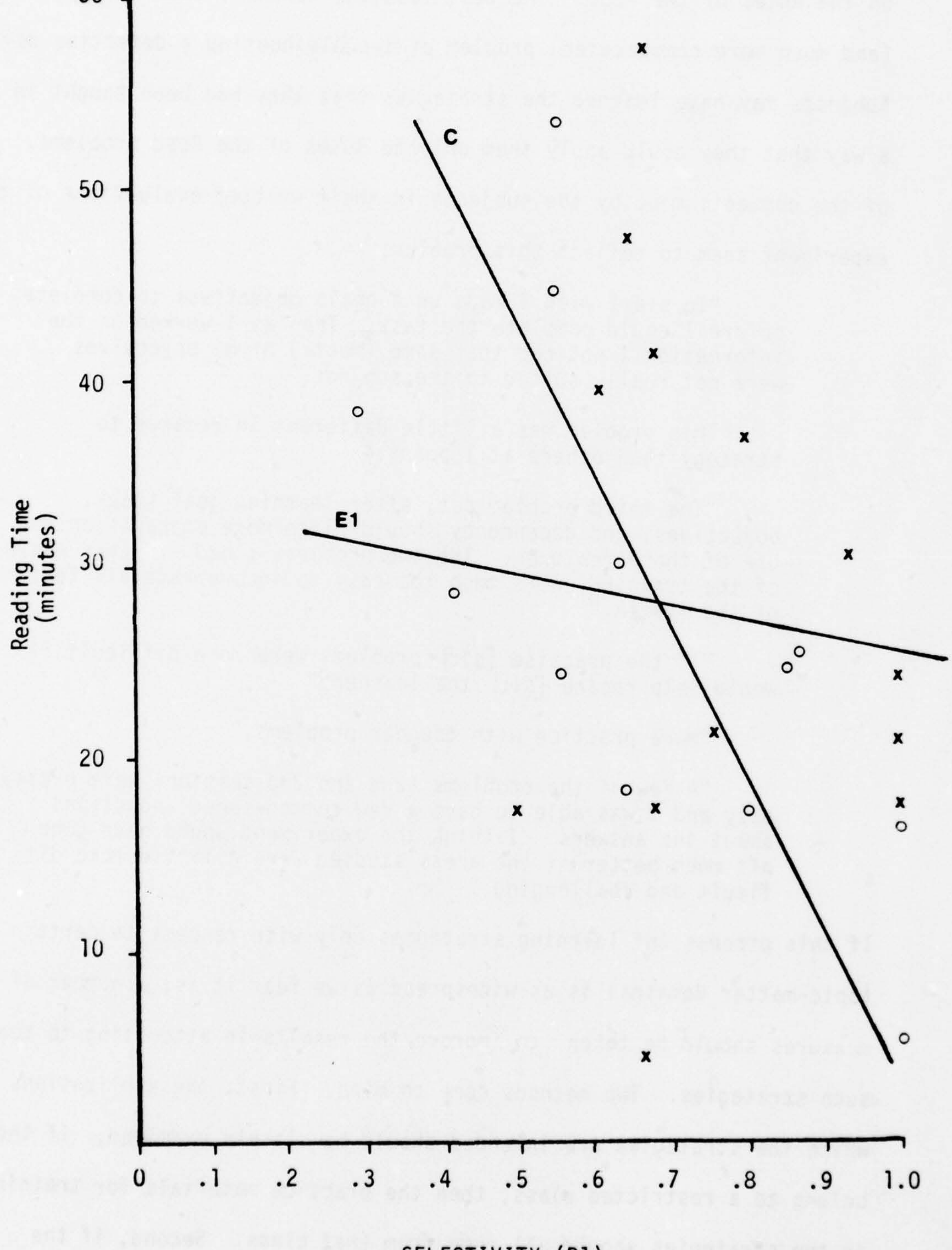

Figure 2. Correlations of selectivity and reading time for training + aids and control groups.
x = E1, o = C

on the Rules of the Road. The test session, however, used a very different (and much more complicated) problem of troubleshooting a defective device. Subjects may have learned the strategies that they had been taught in such a way that they could apply them only to Rules of the Road problems. Some of the comments made by the subjects in their written evaluations of the experiment seem to reflect this problem:

> "To start with I made up 4 goals objectives to complete before I could complete the task. Then as I worked on the information I noticed that some (most?) of my objectives were not really suited to the subject."
>
> "This problem was a little different in regards to strategy than others at 1 point."
>
> "The third problem set, after learning goal stack, objectives, and dependency should place more emphasis on the use of those features. The two problems I had in this phase of the training were much too easy to incorporate all features of the system."
>
> "If the practise [sic] problems were more difficult it would help repare [sic] the learner."
>
> "More practice with tougher problems."
>
> "A few of the problems (2nd and 3rd session) were pretty easy and I was able to have a few common-sense deductions about the answers. I think the experiment would have gone off much better if the areas studied were a little more difficult and challenging."

If this process (of learning strategies only with respect to certain topic-matter domains) is as widespread as we fear it is, a number of measures should be taken to improve the results in attempting to teach such strategies. Two methods come to mind. First, the applications for which the strategies are intended should be closely examined. If they belong to a restricted class, then the practice materials for training in the strategies should all come from that class. Second, if the applications are not members of a restricted class, then as wide a variety of practice problems should be used as is possible. The training process will almost certainly have to be more protracted in such a case.

The second general conclusion about human learning that we have been led to is that adults' learning strategies have been highly automatized. Rigney (1978) has reviewed evidence on this issue. If this claim is true, we should not be surprised to discover that our experimental subjects, who should have been using superior strategies, did not do significantly better than those subjects in the control group. First, it is possible that, for many of our experimental subjects, the highly overlearned old inefficient strategies automatically went into action and competed with the new, less well-learned strategies we had taught them. Second, if some experimental subjects were able to use the new strategies we had taught them, they could have been at a disadvantage with respect to the control subjects who used their old strategies. The control subjects' strategies could be activated automatically, and should have required little conscious control. The new, unfamiliar techniques used by the experimental subjects, however, would surely require considerable conscious control, thus reducing the processing resources available for learning and problem solution. Viewed in this light, the fact that experimental subjects did not do significantly worse than control subjects seems to support the essential validity of the learning techniques embodied in the aids system.

BIBLIOGRAPHY

Gordon, L., Munro, A., Rigney, J. W., & Lutz, K. A. Summaries and recalls for three types of texts. (Tech. Rep. No. 85.) Los Angeles: University of Southern California, Behavioral Technology Laboratories, May 1978.

Goldstein, I. & Papert, S. Artificial intelligence, language, and the study of knowledge. Cognitive Science, 1977, 1, 84-123.

Munro, A., Rigney, J. W., & Crook, D. E. A formative evaluation of a computer-based instructional system for teaching job-oriented reading strategies. (Tech. Rep. No. 84). Los Angeles: University of Southern California, Behavioral Technology Laboratories, January 1978.

Rigney, J. W. Cognitive learning strategies and dualities in the human information processing system. Paper presented at the Conference on Aptitude, Learning, and Instruction: Cognitive Process Analysis, San Diego, March 9, 1978.

Rigney, J. W., Munro, A., & Crook, D. E. Teaching task-oriented selective reading strategies. In H. F. O'Neil (Ed.), Learning strategies II: Measures and modules. New York: Academic Press, in press.

Rumelhart, D. E. & Ortony, A. The representation of knowledge in memory. in R. C. Anderson, R. J. Spiro, & W. E. Montague (Eds.), Schooling and the acquisition of knowledge. Hillsdale, New Jersey: Lawrence Earlbaum Associates, 1977.

APPENDIX

Prescriptive Schemata Attained as a Result of

Training in Self-directed Learning Strategies

```
(1)  SELF-DIRECTED-LEARNING (TASK)
          is when
     BUILD-GOAL-STRUCTURE (TASK)
     TASK-PURSUE (TASK)
          end.
(2)  BUILD-GOAL-STRUCTURE (TASK)
          is when
     ANALYZE (TASK, for OBJECTIVES (TASK))*
     PREREQUISITE-SEARCH (For EACH (OBJECTIVE), IN OBJECTIVES)
     PREREQUISITE-SEARCH (for EACH (OBJECTIVE), in CONTENTS)
          end.
(3)  TASK-PURSUE (TASK)
          is when
     EXAMINE (GOAL-STRUCTURE)
     UNTIL (CHECKED (EVERY (OBJECTIVE)), PURSUE (OBJECTIVE))
     TASK-ATTEMPT  (TASK)
          end.
(4)  TASK-ATTEMPT  (TASK)
          is when
     IF (DO (TASK), then QUITE, else SELF-DIRECTED-LEARNING (TASK))
          end.
```

*The ANALYZE sub-schema has not yet been represented. How people are able to discover the prerequisites or component actions of a task is not well understood.

```
(5)  PREREQUISITE-SEARCH (for GOALS, in SUBGOAL-SET)
         is when
     FOR-EACH (MEMBER, of SUBGOAL-SET),
         IF (PREREQUISITE (MEMBER, for GOAL),
         then (SPECIFY-DEPENDENCY (MEMBER, to OBJECTIVES-LIST))))
         end.
(6)  PURSUE (GOAL)*
         is when
     FOR-EACH (SUBGOAL  (NECESSARY (SUBGOAL, to GOAL)) in GOAL-STRUCTURE,
         WHILE (ANY (UNSATISFIED (SUBGOAL'(NECESSARY (SUBGOAL', to
         SUBGOAL))))'.
             PURSUE (SUBGOAL'))
         TRIAL (SUBGOAL ))
             end.
(7)  UNSATISFIED (GOAL)
         is when
     NOT (CHECKED (GOAL))
     NOT (ELIMINATED (GOAL))
         end.
(8)  TRIAL (GOAL)
         is when
     ATTEMPT (ACTION, of GOAL)
     EVALUATE (GOAL)
         end.
```

*This structure is a variant of Rumelhart & Ortony's (1977) schema for TRYing, a subschema of their PROBLEM-SOLVING schema.

```
(9)  EVALUATE (GOAL)
         is when
     IF (NECESSARY (GOAL, to HIGHER-GOAL),
         then IF (SATISFIED (GOAL), then CHECK (GOAL),
              else TASK-PURSUE (TASK),
         else ELIMINATE (GOAL, from GOAL-STRUCTURE))
         end.
(10) ATTEMPT (GOAL)
         is when
     IF (BELIEVE (CAUSE (ACTION, SATISFIED (GOAL))),
         then DO (ACTION),
         else when SUCCEED (PREREQUISITE-SEARCH (for GOAL)),
              ATTEMPT (PREREQUISITE (GOAL)))
         end.
```

According to the first of these schemata, the student believes that the way to achieve a task through self-directed learning is first to build a goal structure and second to pursue the task, using that goal structure. The second schema listed above describes what is involved in building a goal structure. One analyzes a task for objectives (subgoals necessary for the performance of the task), then one searches for prerequisite relationships among these objectives, between the available information resources and the objectives, and among the relevant available information sources. However, the schema does not contain explicit reference to the process of adding these relationships to the goal structure, because the goal structure is constructed for the student by the program that aids him or her in self-directed learning. The fifth schema listed above is an essential part of the goal-structure-building schema, since it specifies how the search for prerequisites is conducted.

The second major part of self-directed learning, after building a goal structure, according to the above schemata, is to pursue the task. The third schema above gives the top-level structure for task pursuit. One examines the newly constructed goal structure first; then one pursues the objectives included in that goal structure until every one of them has been checked. (Checking is the process by which a student marks the attainment of a subgoal, using the Aids program on PLATO). When all the necessary objectives have been checked, the student attempts the task. If the attempt fails (see schema #4), then he begins the self-directed learning process again, reconstructing or modifying the goal structure.

The pursuits of objectives is governed by the sixth schema given above. This is a recursive procedure that traces down dependency relationships in the goal structure. When a goal is found that has no prerequisites, that goal is subjected to a trial. This means (see #8, 9 & 10) that the student does an action to bring about the goal and then evaluates the results of that action. If the goal is satisfied, he checks the goal and then pops back to the appropriate point in the procedure that is pursuing an objective. If it is not satisfied, he looks for a new way to pursue his overall task. If the attempt reveals that the goal was unnecessary to the attainment of its higher goal, then it is dropped from the goal structure.

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